REMARKS

Claims 1-19 remain in the application. Claims 1-19 have been rejected.

Applicant respectfully responds to this Office Action.

Claim Rejections under 35 U.S.C. § 102

Claims 1-11 and 15-19 were rejected under 35 U.S.C. § 102(e) as being anticipated by U.S. Patent Publication 2002/0150065 to Ponnekanti (hereinafter "Ponnekanti").

"A claim is anticipated only if each and every element as set forth in the claim is found, either expressly or inherently described, in a single prior art reference." M.P.E.P. § 2131 (Aug. 2001) (*quoting Verdegaal Bros. v. Union Oil Co. of California*, 814 F.2d 628, 631, 2 USPQ2d 1051, 1053 (Fed. Cir. 1987)). "The identical invention must be shown in as complete detail as is contained in the . . . claim." *Id.* (*quoting Richardson v. Suzuki Motor Co.*, 868 F.2d 1226, 1236, 9 USPQ2d 1051, 1053 (Fed. Cir. 1987)). In addition, "the reference must be enabling and describe the applicant's invention sufficiently to have placed it in possession of a person of ordinary skill in the field of the invention." *In re Paulsen*, 30 F.3d 1475, 1479, 31 USPQ2d 1671, 1673 (Fed. Cir. 1994)

Applicants respectfully submit that claims 1-11 and 15-19 are not anticipated by Ponnekanti for the reasons and explanations set forth below.

With respect to claims 1 Applicant respectfully submits that Ponnekanti does not teach or suggest all of the limitations of amended claim 1. In particular, Ponnekanti does not disclose "a quality measurement unit for iteratively measuring link quality of a communication link; a quality message processing unit for generating a quality message and multiple differential indicators based on the measured link quality".

Ponnekanti discloses communication systems in four embodiments. The first embodiment discloses the fact that a plurality of transmission paths may exist between a base station and a mobile unit. This embodiment forms a directional transmission beam for each transmission path and transmits a separate transmission signal in each transmission beam. Each of the transmission

signals is encoded differently using a space-time diversity scheme in order to reduce interference between the signals. (Paragraph 0153)

The second embodiment of Ponnekanti uses path diversity in the downlink between the base station and a mobile unit, with different channel coding applied to each transmission signal. The channel coding for each transmission signal is chosen so as to reduce the cross-correlation between the transmission signals, thus reducing interference. (Paragraph 0186)

The third embodiment disclosed by Ponnekanti provides that the transmission signals from a base station to a mobile station are monitored, and if a transmission signal has faded then transmission of that signal is suspended to reduce interference to other transmission signals. The decision whether to suspend transmission of a transmission signal is based on a feedback signal which is sent from the mobile unit to the base station. (Paragraph 0207)

The fourth embodiment of Ponnekanti discloses a time advance that is selectively applied to certain transmission signals so that different transmission signals transmitted via different transmission paths arrive at a mobile unit in approximate time synchronization, thus maintaining the orthogonality between the transmission signals. (Paragraph 0245)

The Examiner states that "Ponnekanti disclosed 'Communication Systems' and a method for wireless communication system comprising, a quality measurement unit [items 262, 264 of Fig. 11] for iteratively measuring link quality of a communication link, a quality message processing unit [item 266 of Fig. 11] for generating a quality message based on the measured link quality and for generating a parity check (BER) corresponding to the quality message, and a differential analyzer for determined changes in the measured quality.[Figs. 11-16, Paragraphs 001-0119, 0216-0224]." Applicant respectfully disagrees with the Examiner's statement for the reasons set forth below.

The cited portions read as follows:

> [0001] The present invention relates to communications systems, and in particular communications systems for use in multi-path, multi-user environments, such as cellular mobile communications systems.
>
> [0002] In a cellular mobile communications system, the area to be served by the system is divided into a plurality of cells, each of which is served by a base station. Within each cell, it is necessary for the base station to transmit to each wanted user (i.e. each active mobile unit) in a multi-user and multi-path environment. In order to achieve satisfactory

signal detection at low bit error rates, the multi-user interference (MUI), sometimes referred to also as multiple access interference (MAI), must be reduced to an acceptable level.

[0003] Code division multiple access (CDMA) is a multiplexing technique which is considered suitable for use in mobile cellular communications systems due to its spectral efficiency (leading to the accommodation of more users) and its relative immunity to interference. In cellular mobile communications systems employing CDMA, each signal to be transmitted from the base station to a mobile unit is spread over a wide bandwidth at the base station using a unique spreading code. Each mobile unit despreads one of the wide bandwidth signals back to the original signal using a replica of the spreading code that was used to spread that signal. Other wide bandwidth signals, which were spread with different spreading codes, are not despread, and thus these signals appear at the mobile unit only as background interference. The spreading codes are generally chosen to be orthogonal, or nearly orthogonal. In this way the transmitted signals themselves are made orthogonal, so that interference between the signals is minimized.

[0004] An advantage of CDMA is that signals transmitted to a mobile unit via different transmission paths can be resolved (i.e. detected independently) by the mobile unit, provided the signals have sufficiently large differential time delays. This can allow transmission signals transmitted via different paths to be detected separately at the mobile unit and then combined so as to increase the quality of the signals. However, differential time delays between transmission signals received by a mobile unit via different transmission paths can lead to interference between those signals. The increased interference may be due to signals transmitted to the same mobile unit via different transmission paths interfering with each other, or signals transmitted to different mobile units interfering with each other (MUI).

[0005] In an article by Y. J. Guo et al entitled "Advanced base station technologies for UTRAN", Electronics & Communications Engineering Journal, June 2000, the entire content of which is incorporated herein by reference, it is proposed to employ adaptive antennas at base stations to form directional transmission beams for each user according to its location. Using an adaptive antenna, a relatively narrow transmission beam pointing at the wanted user and with nulls in the direction of strong interferers can be produced, so that MUI experienced by each user can be reduced.

[0006] The system proposed by Guo et al is effective in reducing the MUI experienced by each user. However, where two paths with a wide angular separation exist between the base station and a mobile unit, either the transmission beam must be broad enough to encompass both of the paths, or one of the paths must be excluded from the transmission beam, which may reduce the effectiveness of the system. Furthermore, the proposed system does not solve the problem of differential time delays leading to interference between the signals transmitted to the same user via the various paths.

[0007] It is therefore desirable to provide a system which overcomes the problems mentioned above. In particular it is desirable to provide a system in which interference between signals transmitted to a user via different transmission paths is reduced.

SUMMARY OF THE INVENTION

[0008] According to a first aspect of the present invention there is provided a transmitting apparatus for transmitting a signal to a receiving apparatus, comprising:

[0009] transmitting means for transmitting a plurality of directional transmission beams to the receiving apparatus via different transmission paths, each transmission beam carrying a transmission signal representing the signal to be transmitted; and

[0010] coding means for coding the transmission signals carried by the transmission beams;

[0011] wherein the coding means is arranged to code the transmission signal carried by one transmission beam differently from the transmission signal carried by another transmission beam.

[0012] By transmitting a plurality of directional transmission beams to the receiving apparatus via different transmission paths, and arranging the coding means to code the transmission signal carried by one transmission beam differently from the transmission signal carried by another transmission beam, interference between the transmission signals may be reduced.

[0013] For example, by appropriate choice of the coding applied to the various transmission signals, the cross-correlation between the transmission signals may be reduced, which may reduce the interference between the signals. Thus the coding means may be arranged to code the transmission signals such that the cross-correlation between the transmission signals is lower than would be the case if different coding were not employed.

[0014] In one example the coding means is arranged to apply different error protection codes, such as different channel codes, to the transmission signals. For example, the coding applied by the coding means may be one or more of convolution coding, turbo coding, block coding and interleaving.

[0015] In another example the coding means is arranged to apply space-time coding to each of the transmission signals. The space-time encoding means may be arranged to transmit an item of data in different transmission beams at different times. An item of data may be of any arbitrary length, such as one or more bits or bytes or symbols or frames. For example, the coding means may be arranged such that a first transmission signal comprises two sequential symbols and a second transmission signal comprises the

two symbols in reverse order. In this way the same symbol is transmitted via different transmission paths at different times, which may reduce the effect of fading of the transmission paths, or of bursts of interference. One of the symbols in one of the transmission signals may be the complex conjugate of the corresponding symbol in the other transmission signal, and one of the symbols in one of the transmission signals may be the inverse of the complex conjugate of the corresponding symbol in the other transmission signal. If the transmission signals are coded in this way, by appropriate processing of the received transmission signals, the effect of differential time delays between the transmission signals can be reduced or cancelled.

[0016] Alternatively or in addition the coding means may be arranged to apply a different spreading code and/or a different scrambling code to each of the transmission signals, which may improve the quality of the signal obtained by the receiving apparatus.

[0017] Preferably, transmission beams are allocated dynamically to transmission paths as new transmission paths appear and old transmission paths disappear. Thus the apparatus may further comprise detecting means for detecting the presence of transmission paths between the transmitting apparatus and the receiving apparatus, and allocating means for allocating transmission beams to at least some of the transmission paths detected by the detecting means. The detecting means may detect the presence of transmission paths, for example, based on the presence of signals which are received by the transmitting apparatus from the receiving apparatus.

[0018] If the transmitting apparatus and the receiving apparatus move relative to each other, then the directions of the transmission paths may change. Thus the apparatus may further comprise estimating means for estimating the directions of the transmission paths, and adjusting means for adjusting the directions of transmission of the transmission beams based on the directions estimated by the estimating means.

[0019] In operation, the amplitude of a received signal may fluctuate due to transmission conditions. For example, scattering of radio waves may lead to different versions of a transmission signal arriving at the receiver with different delays. Depending on the relative delays, the scattered waves may interfere constructively or destructively, leading to an increase or a decrease in the amplitude of the received signals. The wavelength of the transmission signal determines whether the scattered waves interfere constructively or destructively.

[0020] A reduction in the amplitude of a received signal is referred to as fading. If a transmission signal has faded, then it may be preferable to suspend transmission of that transmission signal for the duration of the fade, so as to reduce interference to other transmission signals. One way of determining whether a transmission signal has faded would be to monitor a corresponding reception signal that was transmitted via the same transmission path, but in the opposite direction, to determine if that reception signal had faded. However, if the reception signal is at a different frequency to the transmitted

signals, then the reception signals may be faded while the transmission signal is not, and vice versa. Thus it may not be appropriate to suspend transmission of a transmission signal on the basis of a corresponding reception signal.

[0021] In an embodiment of the invention, the above problem is overcome by receiving a feedback signal indicating the quality of the various transmission paths, and suspending transmission on a transmission path if it is judged from the feedback signal that that transmission path has faded. Thus the apparatus may further comprise receiving means for receiving from the receiving apparatus a feedback signal indicating the quality of the transmission beams, and selecting means for selecting at least some of the transmission beams based on the feedback signal, the transmitting means being arranged to transmit a transmission signal representing the signal to be transmitted only in the transmission beams selected by the selecting means. The selecting means may be arranged to compare, for each transmission beam, a measure of the quality of that beam (derived from the feedback signal) with a threshold value, and to select those transmission beams with a quality measure above the threshold. Alternatively, the selecting means may be arranged to compare the various quality measures with each other and to select one or more transmission beams with the best relative quality. A combination of the two approaches may be used, with the selecting means selecting the best of those transmission beams with a quality measure above a threshold.

[0022] In the above embodiment, preferably the transmitting means is arranged to transmit a control signal in a transmission beam not selected by the selecting means. By transmitting such a control signal, it is possible to continue to monitor the quality of the transmission path, so that if fading of the transmission path stops, transmission on that transmission path may be resumed.

[0023] As discussed above, the transmission signals transmitted via different transmission paths may arrive at the receiving apparatus with differential time delays. If the signals have been coded using scrambling codes (so that transmission takes place using CDMA) then orthogonality between the signals may be reduced due to the differential time delays. This loss of orthogonality may be reduced by arranging the transmission signals to arrive at the receiving apparatus substantially in time synchronism. This may be achieved by adjusting the relative timing of the signals. Thus the apparatus may further comprise time adjusting means for adjusting the relative timing of at least two transmission signals such that the two transmission signals transmitted via different transmission paths arrive at the receiving apparatus substantially in time synchronism. For example, one or more of the transmission signals may be time advanced by the appropriate amount, or one or more of the transmission signals may be time delayed by the appropriate amount, or a combination of time advance and time delay may be used. Such a selective time adjustment mechanism may also be used to improve signal quality in non-CDMA systems.

[0024] A receiving apparatus corresponding to the transmitting apparatus described

above may be provided, and thus in a second aspect of the invention there is provided a receiving apparatus for receiving a plurality of transmission signals and outputting a combined signal based on the plurality of transmission signals, comprising:

[0025] receiving means for receiving the plurality of transmission signals carried in respective directional transmission beams via respective transmission paths; and

[0026] decoding means for decoding the plurality of transmission signals;

[0027] wherein the decoding means is arranged to decode one transmission signal differently from another transmission signal.

[0028] The decoding means may be arranged to decode signals which have been coded using different convolution codes, or the decoding means may be arranged to decode signals which have been coded using different turbo codes. The apparatus may further comprise combining means for combining signals decoded by the decoding means to yield the output signal.

[0029] The decoding means may be arranged to decode signals which have been space-time coded. For example, as was discussed above, the same symbol may have been transmitted via different transmission paths at different times, and one of the symbols in one of the transmission signals may be the complex conjugate of the corresponding symbol in the other transmission signal, and one of the symbols in one of the transmission signals may be the inverse of the complex conjugate of the corresponding symbol in the other transmission signal. In this case, the decoding means may comprise channel estimating means for estimating channel vectors of the transmission paths, and combining means for combining the received transmission signals with the channel vectors estimated by the channel estimating means to yield an output signal. This may reduce or cancel the effect of differential time delays between the transmission signals.

[0030] The decoding means may be arranged to descramble signals which have been scrambled using different scrambling codes and/or to despread signals which have been spread using different spreading codes.

[0031] The apparatus may further comprise means for producing measures of a quality of the transmission beams, means for producing a feedback signal based on the measures of the quality of the transmission beams, and means for transmitting the feedback signal from the receiving apparatus to the transmitting apparatus.

[0032] Analogous method aspects are also provided, and thus in a third aspect of the invention there is provided a method of transmitting a signal from a transmitting apparatus to a receiving apparatus, comprising:

[0033] coding a plurality of transmission signals representing the signal to be transmitted,

each transmission signal being coded differently; and

[0034] transmitting a plurality of directional transmission beams from the transmitting apparatus to the receiving apparatus via different transmission paths, each transmission beam carrying a differently coded transmission signal.

[0035] A corresponding receiving method is also provided, and thus in a fourth aspect of the invention there is provided a method of receiving transmission signals, comprising:

[0036] receiving a plurality of transmission signals carried in respective directional transmission beams via respective transmission paths;

[0037] decoding the plurality of transmission signals, one transmission signal being decoded differently from another transmission signal; and

[0038] outputting a combined signal based on the plurality of transmission signals.

[0039] As discussed above, the transmission of data signals in transmission beams which have faded may be suspended to avoid causing interference to other transmission beams. To determine which transmission beams have faded, a feedback signal indicating the quality of the transmission beams may be sent from the receiving apparatus to the transmitting apparatus.

[0040] The above feature may be provided independently and thus, according to a fifth aspect of the invention, there is provided a transmitting apparatus for transmitting a data signal to a receiving apparatus, comprising:

[0041] transmitting means for transmitting a plurality of directional transmission beams to the receiving apparatus via different transmission paths;

[0042] receiving means for receiving from the receiving apparatus a feedback signal indicating a quality of the transmission beams; and

[0043] selecting means for selecting at least one of the plurality of transmission beams based on the feedback signal;

[0044] wherein transmitting means is arranged to transmit the data signal only in those transmission beams selected by the selecting means.

[0045] Preferably the selecting means is arranged to determine whether the transmission beams have faded and to select transmission beams which are not faded. For example, the selecting means may be arranged to compare, for each transmission beam, a measure of the quality of that beam (derived from the feedback signal) with a threshold value, and to select those transmission beams with a quality measure above the threshold.

Alternatively, the selecting means may be arranged to compare the various quality measures with each other and to select one or more transmission beams with the best relative quality, or a combination of the two approaches may be used.

[0046] If a transmission beam is likely to cause significant interference to other transmission beams, then it may be preferred not to transmit a data signal in that transmission beam even if the transmission beam has not faded. Such a situation may arise, for example, if the data signal is a high data rate signal and other transmission beams are to be transmitted in similar directions. Thus the selecting means may be arranged to select transmission beams additionally based on the relative powers and/or directions of the transmission beams.

[0047] The transmitting means may be arranged to transmit a control signal in a transmission beam not selected by the selecting means, which control signal is for use in measuring the quality of the transmission beam. Such a control signal may be of relatively low power, and thus cause little interference to other signals.

[0048] The feedback signal may comprise a number of feedback symbols equal to the number transmission beams, and each feedback symbol may indicate whether one of the transmission beams has faded. Each feedback symbol may be, for example, a codeword, or simply one or more bits. Alternatively the feedback signal may comprise measures of the quality of each of the transmission beams. In the latter case the receiving means may be arranged to receive the quality measures for different transmission beams at different times on a predetermined time division multiplexing basis.

[0049] The apparatus may further comprise means for altering signals to be carried by the transmission beams such that the signals are distinguishable from each other. In this way the receiving apparatus can distinguish between the various transmission beams and thereby obtain a measure of a quality of each of the transmission beams. However, the receiving apparatus may be able to distinguish between various transmission beams, for example, based on different times of arrivals of the corresponding transmission signals.

[0050] A corresponding receiving apparatus is also provided, and thus according to a sixth aspect of the invention there is provided a receiving apparatus for receiving signals transmitted by a transmitting apparatus, comprising:

[0051] receiving means for receiving a plurality of directional transmission beams transmitted via different transmission paths;

[0052] means for producing measures of a quality of the transmission beams;

[0053] means for producing a feedback signal based on the measures of the quality of the transmission beams; and

[0054] means for transmitting the feedback signal from the receiving apparatus to the transmitting apparatus.

[0055] The apparatus may be arranged to output a combined signal based on a plurality of received signals. Thus, if the data signal is transmitted via a plurality of different transmission beams, all of the received signals may be combined to produce the combined signal. By combining the received signals in this way, the quality of the signals may be improved.

[0056] Preferably the feedback signal is for use in determining whether the transmission beams have faded.

[0057] The receiving means may be arranged to receive control signals in each of the transmission beams, and the means for producing quality measures may be arranged to produce measures of the quality of the transmission beams based on measures of the quality of the control signal.

[0058] The feedback signal may comprise a number of feedback symbols equal to the number transmission beams, each feedback symbol indicating whether one of the transmission beams has faded. Alternatively the feedback signal may comprise measures of the quality of each of the transmission beams. In the latter case the quality measures for different transmission beams may be transmitted at different times on a predetermined time division multiplexing basis.

[0059] The apparatus may further comprising means for distinguishing signals carried by different transmission beams, to allow the qualities of the various transmission beams to be determined.

[0060] Analogous method aspects are also provided, and thus in a seventh aspect of the present invention there is provided a method of transmitting a data signal from a transmitting apparatus to a receiving apparatus, comprising:

[0061] transmitting a plurality of directional transmission beams from the transmitting apparatus to the receiving apparatus via different transmission paths;

[0062] receiving the plurality of directional transmission beams;

[0063] producing measures of a quality of the transmission beams;

[0064] producing a feedback signal based on the measures of the quality of the transmission beams;

[0065] transmitting the feedback signal from the receiving apparatus to the transmitting apparatus;

[0066] receiving the feedback signal;

[0067] selecting at least one of the plurality of transmission beams based on the feedback signal; and

[0068] transmitting the data signal only in the selected transmission beams.

[0069] As discussed above, the relative timing of the transmission signals may be adjusted such that transmission signals transmitted via different transmission paths arrive at the receiving apparatus substantially in time synchronism. This feature may also be provided independently, and thus according to a eighth aspect of the present invention there is provided a transmitting apparatus for transmitting a plurality of transmission signals, comprising:

[0070] transmitting means for transmitting a plurality of directional transmission beams, each transmission beam carrying a transmission signal; and

[0071] time adjusting means for adjusting the relative timing of at least two transmission signals such that, when the corresponding transmission beams are received at a receiving apparatus via different transmission paths the two transmission signals are substantially in time synchronism.

[0072] By arranging the transmission signals to be received substantially in time synchronism, interference between the signals may be reduced.

[0073] The time adjusting means may be arranged to adjust the relative timing of the two transmission signals in dependence on a measure of the relative propagation delay of the corresponding transmission paths. The apparatus may further comprise means for measuring the relative propagation delay of the transmission paths. Alternatively, the measure of the relative delay may be sent from the receiving apparatus to the transmitting apparatus, and thus the apparatus may further comprise means for receiving the measure of the relative propagation delay from the receiving apparatus. The receiving apparatus may be, for example, a mobile unit, or some other apparatus which is provided for measuring and feeding back the relative propagation delay.

[0074] In one example, the two transmission signals both represent a signal to be transmitted to the receiving apparatus. In another example, one transmission signal represents a signal to be transmitted to the receiving apparatus and the other transmission signal represents a signal to be transmitted to a different receiving apparatus.

[0075] The apparatus may further comprise means for selecting transmission signals which are to have their relative timing adjusted, based on the relative directions and/or powers of the corresponding transmission beams. For example, the transmission signals

may be selected if the corresponding transmission beams are high power, which may arise, for example, if the transmission signals are high data rate signals. Alternatively, the transmission signals may be selected because one or more of the corresponding transmission beams is transmitted in a direction of high transmission power. This situation may arise due to one high data-rate user or several lower data-rate users transmitting in that direction. By selecting the transmission beams which are to have their relative timing adjusted in this way, interference can be minimized in areas where the most interference would otherwise be caused, which enhances the overall performance of the system.

[0076] The apparatus may further comprise means for applying orthogonal spreading and/or scrambling codes to the two transmission signals. In this way the transmission signals can be separated at the receiving apparatus.

[0077] The invention extends to corresponding receiving apparatus, and thus in a ninth aspect of the invention there is provided receiving apparatus for receiving signals transmitted by a transmitting apparatus, comprising:

[0078] receiving means for receiving a plurality of directional transmission beams transmitted via different transmission paths, each transmission beam carrying a transmission signal;

[0079] means for measuring a relative propagation delay of the transmission signals;

[0080] means for producing a feedback signal based on a measure of the relative propagation delay; and

[0081] means for transmitting the feedback signal from the receiving apparatus to the transmitting apparatus.

[0082] The receiving apparatus may be, for example, a mobile unit, or some other apparatus which is provided for measuring and feeding back the relative propagation delay.

[0083] Corresponding method aspects are also provided, and thus in a tenth aspect of the invention there is provided a method of transmitting a plurality of transmission signals, comprising:

[0084] adjusting the relative timing of at least two transmission signals; and

[0085] transmitting a plurality of directional transmission beams, each transmission beam carrying a transmission signal;

[0086] wherein the relative timing of the at least two transmission signals is adjusted such

that, when the corresponding transmission beams are received at a receiving apparatus via different transmission paths the two transmission signals are substantially in time synchronism.

[0087] Any of the above transmitting apparatuses may further comprising detecting means for detecting the presence of the transmission paths between the transmitting apparatus and the receiving apparatus, and allocating means for allocating transmission beams to at least some of the transmission paths detected by the detecting means. Furthermore, any of the above transmitting apparatuses may further comprise estimating means for estimating the directions of the transmission paths and adjusting means for adjusting the directions of transmission of the transmission beams in dependence on the directions estimated by the estimating means.

[0088] Any of the above transmitting apparatuses may further comprise means for applying spreading codes to the transmission signals to enable code division multiple access transmission. Similarly, any of the above receiving apparatuses may further comprising means for despreading transmission signals which have been transmitted using code division multiple access transmission.

[0089] Any of the above transmitting apparatuses may further comprising a plurality of beam formers and a plurality of antenna elements for producing the plurality of directional transmission beams.

[0090] The invention also extends to a base station for use in a mobile cellular communications system comprising transmitting apparatus in any of the forms described above. The invention also extends to a mobile unit for use in a mobile cellular communications system comprising receiving apparatus in any of the forms described above.

[0091] The invention also extends to a communications system comprising transmitting apparatus in any of the forms described above and receiving apparatus in any of the forms described above. The system may comprise more than one receiving apparatus (e.g. mobile units).

[0092] In a eleventh aspect of the invention there is provided a transmitting apparatus for transmitting a signal to a receiving apparatus, comprising:

[0093] an antenna array;

[0094] a transmitter array connected to the antenna array; and

[0095] a plurality of beam formers connected to the transmitter array, each beam former being operable to receive a transmission signal and to modify the transmission signal, such that the antenna array produces a plurality of directional transmission beams

carrying respective transmission signals; and

[0096] a channel encoder operable to encode each of the transmission signals according to a different code.

[0097] In a twelfth aspect of the present invention there is provided a receiving apparatus for receiving a plurality of transmission signals and outputting a combined signal based on the plurality of transmission signals, comprising:

[0098] a receiver operable to receive a plurality of transmission signals carried in respective directional transmission beams via respective transmission paths, and to separate the plurality of transmission signals; and

[0099] a channel decoder for decoding each of the transmission signals differently from the other transmission signals.

[0100] In a thirteenth aspect of the invention there is provided a transmitting apparatus for transmitting a data signal to a receiving apparatus, comprising:

[0101] an antenna array;

[0102] a transmitter array connected to the antenna array;

[0103] a plurality of beam formers connected to the transmitter array, each beam former being operable to receive a transmission signal and to modify the transmission signal, such that the antenna array produces a plurality of directional transmission beams carrying respective transmission signals;

[0104] a receiver operable to receive from the receiving apparatus a feedback signal indicating a quality of the transmission beams; and

[0105] a processor programmed to produce the transmission signal, to select at least one of the plurality of transmission beams based on the feedback signal and to insert the data signal only in those transmission signals which correspond to the selected transmission beams.

[0106] In a fourteenth aspect of the invention there is provided a receiving apparatus for receiving signals transmitted by a transmitting apparatus, comprising:

[0107] a receiver operable to receive a plurality of directional transmission beams transmitted via different transmission paths;

[0108] a processor programmed to produce measures of a quality of the transmission beams and to produce a feedback signal based on the measures of the quality of the

transmission beams; and

[0109] a transmitter operable to transmit the feedback signal from the receiving apparatus to the transmitting apparatus.

[0110] In a fifthteenth aspect of the invention there is provided a transmitting apparatus for transmitting a plurality of transmission signals, comprising:

[0111] an antenna array;

[0112] a transmitter array connected to the antenna array;

[0113] a plurality of beam formers connected to the transmitter array, each beam former being operable to receive a transmission signal and to modify the transmission signal, such that the antenna array produces a plurality of directional transmission beams carrying respective transmission signals; and

[0114] a processor programmed to adjust the relative timing of at least two transmission signals such that, when the corresponding transmission beams are received at a receiving apparatus via different transmission paths the two transmission signals are substantially in time synchronism.

[0115] In this specification, a directional transmission beam is preferably a transmission beam which has a greater power in one direction than in another direction. The 3 dB beamwidth (i.e. the angular width of the beam where the beam strength is 3 dB below that in the centre of the beam) may be chosen and/or adjusted as required. In one example the 3 dB beamwidth is less than 90.degree., and preferably less than 60.degree. or less than 45.degree. or less than 30.degree., although it may be more than any of these values.

[0116] Features of one aspect may be applied to any other aspect. Apparatus features may be applied to method aspects and vice versa.

[0117] In any of the above aspects the various features may be implemented in hardware, or as software modules running on one or more processors.

[0118] The invention also provides computer programs and computer program products for carrying out any of the methods described herein, and computer readable media having stored thereon programs for carrying out any of the methods described herein. A computer program embodying the invention may be stored on a computerreadable medium, or it could, for example, be in the form of a signal such as a downloadable data signal provided from an Internet web site, or it could be in any other form.

[0119] Preferred features of the present invention will now be described, purely by way of example, with reference to the accompanying drawings.

[0216] Parts of a mobile unit according to the third embodiment will now be described with reference to FIG. 11. The mobile unit comprises antenna 250, duplexer 252, receiver 254, descramblers/despreaders 255, 256, combiner 257, matched filters 258, 260, beam quality indicators 262, 264, feedback signal generator 266, multiplexer 268 and transmitter 270. In operation, transmission beams from the base station are received by antenna 250 and passed to duplexer 252, which separates received and transmitted signals. The radio frequency signals received by antenna 250 are passed to receiver 254, which down-converts the signals and digitizes the down-converted signals. Each of the descramblers/despreaders 255, 256 then descrambles and/or despreads a signal which has been scrambled or spread with a particular spreading or scrambling code and which has been received via a particular transmission path. The descramblers/despreaders 255, 256 may, for example, comprise descramblers, despreaders and integrators similar to those shown in FIGS. 6 and 9. The despread and descrambled signals are then combined in combiner 257.

[0217] Each despread signal is also passed to a respective matched filter 258, 260. The matched filters 258, 260 are matched to the distinguishing characteristics which were inserted into the transmission signals by the base station. For example, if different pilot signals were added to the two transmission paths by multiplexers 82, 92 in FIG. 4, then filters 258, 260 are each matched to one of those pilot signals. In certain circumstances, for example if different spreading or scrambling codes were used by spreaders 86, 96 or scramblers 84, 94 in FIG. 4, then filters 258, 260 may be omitted, since the various signals are distinguished by descramblers/despreaders 255, 256.

[0218] The outputs of filters 258, 260 are fed to respective beam quality indicators 262, 264. Each beam quality indicator produces a measure of the quality of the signals transmitted via the corresponding transmission path. Any suitable measure of quality can be produced. For example, a received signal strength (RSS) or power measure, a bit error rate (BER) or a frame error rate (FER) measure, or a signal-to-interference ratio (SIR) or a signal-to-interference-and-noise ratio (SINR) measure could be produced. The measure could be based on a pilot signal inserted by the base station, for example by multiplexer 82 or 92 in FIG. 4 or multiplexer 123, 133 or 143 in FIG. 7. Alternatively, the measure could be a transmission power control (TCP) bit generated in the mobile unit for downlink power control purposes. Any of the measures could be based on a history or average of measurements taken over several measurement periods (e.g. time slots) to avoid possible instability when two or more of the transmission paths have approximately the same instantaneous quality.

[0219] The measures produced by the beam quality indicators 262, 264 are fed to feedback signal generator 266. Feedback signal generator 266 produces a feedback signal for transmission from the mobile unit to the base station, which feedback signal contains information regarding the various beam qualities as measured by the beam quality indicators 262, 264. The feedback signal is fed to multiplexer 268 to be inserted into a

signal for transmission from the mobile unit to the base station. At the base station the feedback signal is extracted as feedback signal 222, as explained above with reference to FIG. 10.

[0220] When implementing the present embodiment, the frame format shown in FIG. 2 may be used for downlink transmission. The pilot bits contained in the control channel may be used for measuring the quality of the received signals in the beam quality indicators 262, 264.

[0221] In the uplink, the frame format shown in FIG. 3 may be used, and the feedback signal may be sent using the feedback information bits FBI. In one example, a single FBI bit is used for each transmission beam, the bit indicating whether or not the beam has faded. Thus, if two transmission beams were sent, then two feedback symbols would be needed on which to base path selection. Alternatively, a number of FBI bits may be used to indicate the quality of each transmission beam. For example, an output of beam quality estimator 262 may be sent using the FBI bits of one time slot and an output of beam quality estimator 264 sent using the FBI bits of another time slot. Alternatively, the outputs of the beam quality estimators 262, 264 may be sent using the FBI bits of several time slots each. The outputs of the beam quality estimators may be multiplexed with other feedback information which is sent using the FBI bits.

[0222] Operation of the path diversity controller 240 will now be explained with reference to FIG. 12. Referring to FIG. 12, in step 272 the path diversity controller 240 receives an input from path searcher 200 indicating whether a new uplink (reception) path has appeared between the mobile unit and the base station. If a new reception path has appeared, then in step 274 it is determined whether the power of that path is above a certain threshold. This is done by comparing the output of the appropriate power strength estimator 210, 212 in FIG. 10 with a threshold value. If the strength of the reception path is above the threshold, then in step 276 a downlink transmission path is allocated to that reception path. This is done by allocating a path processor (such as path processor 60 in FIG. 4 or path processor 104 in FIG. 7) to that transmission path.

[0223] The path processor may have its own beam former, or it may share a beam former with one or more other path processors. For example, if the differential angle of arrival between two or more paths is greater than a predetermined threshold (for example, the 3 dB beamwidth of a transmission beam) then an individual beam former may be allocated to each transmission path, so that separate transmission beams are formed for each of the paths. For those paths where the differential angle of arrival is less than the predetermined threshold a common beam former may be allocated.

[0224] In step 278 the convolution coding, rate coding and interleaving of the transmission path are adjusted to be appropriate for the transmission conditions. For example, adjustments may be made to take into account the quality of the transmission channel, so that if the channel quality is poor a greater level of redundancy may be added

by the convolution coder and a greater depth of interleaving used.

Applicant respectfully notes that these citations comprise approximately half the Ponnekanti reference and that the Examiner has provided no detailed citations for the cited features. In particular, despite diligent study of the Ponnekanti reference, Applicant finds no disclosure of the limitations "a quality measurement unit for iteratively measuring link quality of a communication link; a quality message processing unit for generating a quality message and multiple differential indicators".

Claims 2 and 3 are each allowable as depending either directly or indirectly from allowable claim 1.

Claim 4 is allowable for the same reasons given above for claim 1.

Claims 5-7 are each allowable as depending either directly or indirectly from allowable claim 4.

Claim 8 is allowable for the same reasons given above for claim 1.

Claims 9 and 10 are allowable as depending directly from an allowable base claim.

Claim 11 is allowable for the same reasons given above for claim 1.

Claim 15 is allowable for the same reasons given above for claim 1. In addition, claim 15 is allowable because Ponnekanti does not disclose the limitation "determining a transmission rate for transmission of quality messages and differential indicators based on the comparison" as found in amended claim 15. The Examiner cites Figs. 11-16, Paragraphs 0001-0119, 0137-0150, 0216-0224, and 0244-0265. Because Ponnekanti does not disclose "differential indicators" it therefore, cannot disclose "transmission of quality messages and differential indicators based on the comparison". Despite careful and diligent study of the Ponnekanti reference Applicant is unable to find any disclosure of the above limitations and respectfully requests that the Examiner provide a detailed citation of the disclosure as the current citation comprises most of the reference.

Claim 16 is allowable for the same reasons given above for claim 1 and claim 15. In addition, Applicant notes that the Examiner cites Figs. 11-16 and paragraphs 0001-0265 for support. Applicant respectfully notes that this citation includes the complete text of the

Ponnekanti reference and requests that the Examiner provide a detailed location of the disclosure.

Claim 17 is allowable as depending directly from an allowable base claim.

Claim 18 is allowable for the same reasons given above for claim 1. In addition, claim 18 is allowable because Ponnekanti does not disclose the limitation found in amended claim 18, "generating differential indicators separately from the quality message". The Examiner cites Figs. 1-16 and paragraphs 0001-0265. Applicant notes that this citation is to the entire Ponnekanti reference. Despite diligent study of the reference, Applicant is unable to locate any teaching, suggestion or disclosure of the limitation and requests that the Examiner provide a detailed citation to the pertinent portion of the Ponnekanti reference.

Claim Rejections under 35 U.S.C. § 103

Claims 12-14 were rejected as being unpatentable over Ponnekanti in view of U.S. Patent Publication 2004/0013103 to Zhang (hereinafter "Zhang"). This rejection is respectfully traversed.

To establish a prima facie case of obviousness, the prior art reference (or references when combined) must teach or suggest all the claim limitations. "The teaching or suggestion to make the claimed combination and the reasonable expectation of success must both be found in the prior art, not in Applicants' disclosure." In re Vaeck, 947 F.2d 488, 20 USPQ2d 1438 (Fed. Cir. 1991).

Applicants respectfully submit that a prima facie case of obviousness has not been established regarding claims 12-14 because the prior art cited does not teach or suggest all the claim limitations. Specifically, the cited prior art does not disclose or suggest the limitation "receive circuitry operative to receive signals on a reverse link, including a quality message with a parity check, and differential indicators, the quality message periodically providing a quality metric of a forward link, wherein the differential indicators track the quality metric between successive quality messages" as found in Applicants' invention.

The Ponnekanti reference has been discussed above and Applicant maintains the arguments given above in regard to the Ponnekanti reference. Applicant respectfully submits that combining Ponnekanti and Zhang does not result in Applicant's invention.

Zhang is directed toward communication of control information in wireless communication systems. (Title) A wireless system has a high rate data channel for time multiplexed communications to multiple mobile stations (MSs). Control channels include a forward link common power control channel and reverse link feedback channels for pilot, forward channel quality, and data acknowledgements from each MS. (Abstract)

Zhang does not teach, suggest or disclose "receive circuitry operative to receive signals on a reverse link, including a quality message with a parity check, and differential indicators, the quality message periodically providing a quality metric of a forward link, wherein the differential indicators track the quality metric between successive quality messages" as found in Applicants' invention. Zhang is directed to the provision of control information, particularly power control information and does not disclose the limitation "receive circuitry operative to receive signals on a reverse link, including a quality message with a parity check, and differential indicators, the quality message periodically providing a quality metric of a forward link, wherein the differential indicators track the quality metric between successive quality messages" as found in Applicants' invention.

Combining Ponnekanti and Zhang does not result in Applicant's invention. The combining of the references produces a communication system that selects transmission beams for transmitting and provides a reverse link communication path for power control information. Applicant respectfully submits that the combination of Ponnekanti and Zhang does not teach, disclose, or suggest an iterative quality measurement with differential indicators between successive quality messages as found in Applicant's claim 12.

Claim 13 is allowable for the same reasons given above for claim 12.

Claim 14 is allowable as depending directly from an allowable base claim.

PATENT

REQUEST FOR ALLOWANCE

In view of the foregoing, Applicant submits that all pending claims in the application are patentable. Accordingly, reconsideration and allowance of this application are earnestly solicited. Should any issues remain unresolved, the Examiner is encouraged to telephone the undersigned at the number provided below.

Respectfully submitted,

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